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Applying Acquisition Lessons Learned to Operational Energy Initiatives

by

Lieutenant Colonel Christine A. Hackett
United States Army

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Land-Power capabilities rely on the availability of operational energy to create conditions for mission success. The US Army has designated a Director of the Operational Energy – Contingency Basing (OE-CB) to monitor the integration of operational energy related initiatives across all warfighter functions. To capitalize on the lessons learned from a decade of acquisition system improvements and war the Director of OE-CB must have more than oversight responsibility to deliver affordable capability. Programmatic and budgetary authority over the entire portfolio is the most effective way to implement an operational energy equipping and modernization strategy. Adoption of the agile acquisition capabilities lifecycle process and the Network Integration Evaluation will enable the OE-CB to partner with industry and government research facilities to focus on deploying mature technologies, while developing the science and technology investment strategies to build an informed and secure operational energy network.

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Lieutenant Colonel Christine A. Hackett
United States Army

Dr. Janeen Klinger
Department of National Security and Strategy
Project Adviser

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U.S. Army War College
CARLISLE BARRACKS, PENNSYLVANIA 17013

Abstract

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Land-Power capabilities rely on the availability of operational energy to create conditions for mission success. The US Army has designated a Director of the Operational Energy – Contingency Basing (OE-CB) to monitor the integration of operational energy related initiatives across all warfighter functions. To capitalize on the lessons learned from a decade of acquisition system improvements and war the Director of OE-CB must have more than oversight responsibility to deliver affordable capability. Programmatic and budgetary authority over the entire portfolio is the most effective way to implement an operational energy equipping and modernization strategy. Adoption of the agile acquisition capabilities lifecycle process and the Network Integration Evaluation will enable the OE-CB to partner with industry and government research facilities to focus on deploying mature technologies, while developing the science and technology investment strategies to build an informed and secure operational energy network.

Applying Acquisition Lessons Learned to Operational Energy Initiatives

Energy has always been a critical requirement for the effective application of land-power. Since World War Two the Department of Defense's operational fuel consumption has grown from one gallon of fuel per soldier per day to 22 gallons per soldier per day for operations in Iraq and Afghanistan (2009).[1] Fifty percent of those 22 gallons are for electricity generation to power information age headquarters, command posts and forward operating bases in treacherous and austere environments. Compounding the issue of increased military consumption are budget constraints, threats to the logistics distribution network, limited infrastructure, global energy market conditions and global climate change. Creative operational energy solutions are needed not just to reduce the consumption trends, but to provide smart-power and change the dynamics of operational energy's impacts on the application of US military land-power in support of US foreign policy.[2]

Army operational energy capability gaps affect all Army warfighting functions and present horizontal integration challenges across the people, organizations, systems, information, and processes that accomplish those functions. Effective solutions will require the Army force management systems to define the performance requirements, and the acquisition system to develop and deploy affordable and sustainable materiel solutions that provide a decisive advantage to accomplish the combatant commanders' current and future strategic land-power objectives.

This research will speak to criticisms of the Army acquisition system's past performance and how recent changes have addressed many of the noted deficiencies and improved overall performance outcomes. While there are many products to close operational energy capability gaps, the individual materiel projects and programs are

not going to solve the short or long term challenges. The adoption of a system of systems programmatic approach similar to Network the Force and the application of the Army's new Agile Capability Life Cycle Process[3] will enable effective and efficient management of all the initiatives under the six billion dollar operational energy Future Years Defense Program budget. Now is the time to invest judiciously in a combination of incremental modernization and revolutionary energy solutions that provide both a return on investment and the power needed to maintain dominance.

Critique of Army Acquisition Past Performance

In April 2009, former Defense Secretary Robert Gates canceled the Army's cornerstone development program, the $87 billion Future Combat System, citing the Army's failure to incorporate into the design the combat lessons from Iraq and Afghanistan.[4] Failure to adapt to changes in the threat and operational environment are a common theme across the 15 Major Defense Acquisition Programs[5] (MDAP) or Major Automated Information System[6] (MAIS) the Army has terminated before completion since 2001.[7] Justified concerns of expensive past failures have eroded public and Congressional confidence in the Army's capacity to deliver performance on time or within budget.

This erosion of confidence is not limited to Army program management. In 2005, then acting Deputy Secretary of Defense, Mr. Gordon England, endorsed an all-encompassing assessment to consider "every aspect" of defense acquisition, which resulted in the Defense Acquisition Performance Assessment (DAPA) Project. This federal advisory panel found over 128 previous studies had been conducted to address perceived problems with the "Big A" and to prevent fraud waste and abuse. The DoD's "Big A" Acquisition process consists of the three major decision support systems: The

Joint Capabilities Integration and Development System (CJCSI 3170.01H), the acquisition (small 'a') process as laid out in DoDI 5000.2, and the Planning, Programming, and Budget Execution System (CJCSI 8501.01B). The theory holds that weapon systems or capabilities are delivered as a result of the integrated actions of these three independent processes. DAPA used the system analysis approach (Figure 1) to reach its conclusion that "actions in each of the processes cause unintended negative consequences that magnify the effects of instability, deviations or changes in any one area. Incompatible actions are often caused by differences in organizational values among process owners and participants." [8]

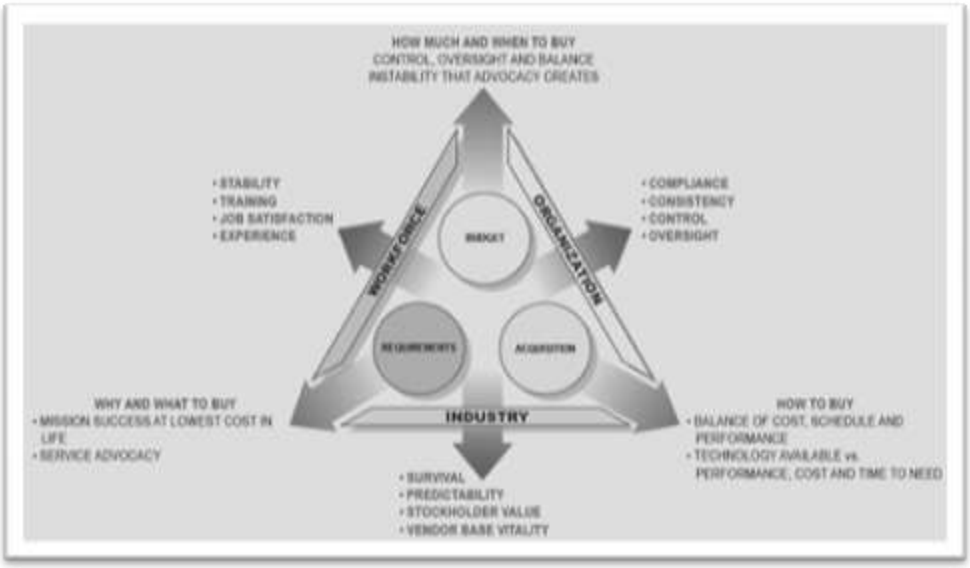

Figure 1: Root Cause Analysis of Stakeholder Driven Program Instability[9]

The aforementioned stakeholder challenges were previously identified by the Packard Commission in their 1986 report which underpinned many of the Goldwater-Nichols mandated acquisition reforms. In their 1999 research, "The Impact of the Packard Commission's Report," David Christensen, David Searle, and Major Caisson Vickey concluded that

> …the [Packard] commission identified the same problems with the acquisition process as in previous decades (cost growth, schedule delays, and performance shortfalls). The commission's recommendations (streamlining the acquisition process, increasing tests and prototyping, changing the organizational culture, improving planning, and adopting the competitive firm model where appropriate) were strikingly similar to reform efforts of the past.[10]

For twenty years the Department of Defense has been in a near constant state of reform that has produced only added layers of oversight and increasing diluted management accountability.[11] The 2010 Department of Defense budget submission validates the lack of improvements with Secretary Gates eliminating at least a half dozen major defense acquisition programs(total projected cost $136B), that were over cost, behind schedule, or no longer suited to meet our warfighters' current performance needs (See Table 1.)[12]

Table 1: GAO Analysis of Defense 2010 Budget Submission[13]

	Weapon system	Secretary's comments
Recommended termination	VH-71 Presidential Helicopter	Plan to develop options for a new program
	Combat Search and Rescue Helicopter	Plan to reexamine requirements
	Next-Generation Bomber	Will not initiate new development program without better understanding of the requirement and technology
	Future Combat Systems–Manned Ground Vehicles	Plan to reevaluate requirements, technology, and approach before relaunching and recompeting program
	Transformational Satellite	Plan to buy two more AEHF satellites as alternative
	Ballistic Missile Defense–Multiple Kill Vehicle	Plan to reexamine requirements; no mention of new program
Recommended end of production	C-17	Recommended ending production at 205 aircraft
	DDG-1000	Recommended ending production at 3 ships
	F-22	Recommended ending production at 187 aircraft

Measuring Cost, Schedule and Performance

As detailed above, program success is about delivering capability to the warfighter, but is measured by the acquisition manager's trinity of cost, schedule, and performance. At the start of the program's inception the program management team is responsible for estimating each of the top level metrics in a variety of ways so as to establish the boundaries of the success box called the Acquisition Program Baseline.[14] This baseline lists clearly defined goals in terms of threshold values (floors or ceilings) and objective values that delineate the expectations for better than threshold performance. While bureaucratic in nature, these metrics are truly warfighter and taxpayer focused seeking to optimize affordable and best solutions. Performance is all about effectiveness as defined by key performance parameters. These parameters can include speed, range, accuracy, survivability, energy efficiency, reliability and other critical characteristics. Schedule is concerned with how long it will take to deliver a compliant system to the warfighter for use. Lastly, development, procurement and lifetime operating cost estimates, to include the fully burdened cost of operational energy, determine if the desired capability and force size is affordable without shorting other needs.[15] Once the baseline is set - delivered to congress and the money is approved - the program's success or apparent failure revolves around keeping inside the success box.

Congressional Oversight

Over concerns that Department of Defense leadership was not addressing affordability, Congress passed a statutory reporting provision known as Nunn-McCurdy Act, which sets thresholds for cost growth reporting. There are two levels of reporting, "significant" and "critical." A significant threshold breach occurs when the program

acquisition unit cost or the procurement unit cost[16] increases by 15 percent over the current baseline or 30 percent over the original baseline for any reason. A critical cost growth threshold breach occurs at the 25 percent and 50 percent level respectively. In the Weapon Systems Reform Act of 2009, Congress mandated program termination if cost growth exceeded the critical threshold unless the Secretary of Defense (SecDef) certified in writing that the program was essential to national security, and that there were no alternatives to the program which would provide acceptable capability. [17]

The increased reporting requirements have not stemmed the problem of cost growth, but they have increased public scrutiny and dissatisfaction. While the Future Combat System was cancelled prior to experiencing a critical Nunn-McCurdy breach, the GAO fully expected it would do so (see table 2) based on changing requirements, immature technology, increasing software code and vehicle weight trends, an aggressive schedule and a lack of knowledge based risk management best practices. [18]

Table 2: FCS Acquisition Program (2003 versus 2009)[19]

	2003	2009	
Cost estimate (Fiscal year 2009 billions of dollars)	Research and development: $20.9	Research and development: $29.0	$8.1 billion increase
	Procurement: $68.2	Procurement: $129.3	$61.1 billion increase
	Total: $89.8	Total: $159.3	$69.5 billion increase
Schedule (Development start to initial operational capability)	7 yr 6 mo	12 yr 3 mo	Over 4-1/2 years added
Requirements	Undefined	System-level requirements not matched with emerging designs	Persistent gaps
Software lines of code	34 million	114 million +	Tripled in size
Projected maturity date of critical technologies[a]	2006	2009	3 years added

In 2010, six major acquisition programs experienced critical cost threshold breaches to include the Army's Apache Block III and Excalibur Artillery Projectile. The root cause analysis reports indicated that while each program had unique

circumstances there were common trends across all six: changes in the economy; misestimation of baseline costs; inadequate program planning; increases in component costs; insufficient Research, Development, Test, and Evaluation; inflation; and increased, inadequate, or unstable program funding. The evidence also suggested that there were clear warning signs of the pending program breaches buried in program documentation.[20]

Earned Value

It is not realistic to expect cost growth to be wholly preventable, but a significant reduction is possible by timely problem recognition and employment of effective mitigation strategies. The program manager's tool of choice for predicting cost and schedule anomalies is the Earned Value Management reporting by the contractor to the government. Mandatory for all cost and incentive contracts over $20M, earned value provides a visual glide path to indicate how well a program is actually keeping to the planned activity schedule and budgeted cost expenditures. Repetitive reporting and causality analysis of all deviations from the planned baseline provides the industry and government management team the information needed for early risk mitigation of cost, schedule, and technical problems. Managers and team members that are held accountable for their actual performance compared to the program baseline are more likely to implement a disciplined process for estimating work and tracking it through completion.[21]

An illustrative example of the benefits of earned value was the implementation earned value practices at Naval Air Systems Command's AV-8B Joint System Support Activity in 2001. Responsible for providing software based capability upgrades to the Harrier fleet, the AV-8B team was exceeding planned delivery cycle time by 30 percent.

Unsatisfied with the level of performance, the leadership team championed the earned value best practices and began documenting organizational standards and processes for all activities into a hierarchical work breakdown structure. Managers responsible for each activity then worked to manage all critical path and resource dependencies within and across projects. Setting these conditions then allowed the team to make corrections based on established thresholds resulting in a 40 percent reduction in delivery time variance.[22]

Earned value management techniques do not eliminate risk or over-runs and are only as good as the baselines, estimates and reported data quality. Citing program restructure and modifications to the acquisition program baseline, the General Accountability Office stated that while the reported data show many components were meeting cost and schedule expectation, the overall Future Combat System earned value projections were inconclusive.[23] Quality earned value data enables disciplined program managers to solve problems early in light of environmental friction, such as funding instability, changing requirements, overly optimistic estimates, performance shortfalls, and even unpredictable 'unknowns' such as a revolutionary advancement in technology, or major changes in defense policy, strategy and priority.[24] In conjunction with good earned value practice General Accountability Office researchers have concluded that leading commercial firms and successful DOD programs produce winning outcomes when they follow a knowledge-based approach to product development.[25]

Knowledge Points

A knowledge-based acquisition replaces high-levels of risk in cost, schedule, and performance parameters with high levels of product knowledge before committing

significant additional resources. The approach is a cumulative process in which certainty and specificity about critical technologies, components, sub-systems, design, integration, as well as space, weight, and power requirements are set as exit criteria before moving into the next phase. [26]

Knowledge based acquisition is not new, it is about adhering to the fundamentals of the DoD Acquisition framework and incorporating bounded requirements balanced with specified delivery time frames. Key knowledge questions should be answered at each phase of development: Do the available resources (technology, time, and funding) match the capability needs before program initiation? If no, redefine requirements to match resources. Is the technology mature? Has it been proven in a relevant environment? If no, then find an alternative technology, modify the requirement, and look to field as a follow-on increment. Ultimately try to avoid simultaneous development of both the critical technology components and the system. The risks imposed by uncertainty correlate to a high probability of cost over-runs, schedule slippage, and non-conforming performance. Know the technology is ready and focus on achieving system development and production capability.[27] Figure 2 below shows the alignment of a knowledge point best practices approach and the Future Combat System (FCS) approach overlaying the phases of the acquisition framework.

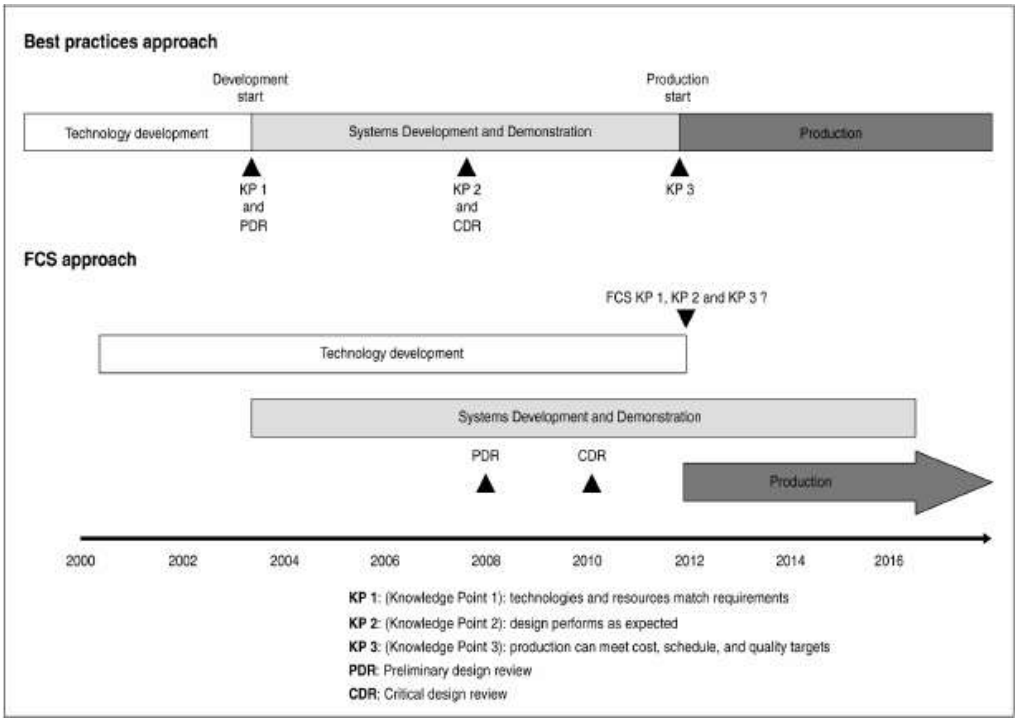

Figure 2: Knowledge Based Best Practices versus the FCS Approach[28]

The Army started the FCS program (Systems Development and Demonstration) in 2003 before ensuring it had met Knowledge Point One requirements 1) a base of mature technologies, 2) well-defined system-level requirements, 3) system functions, 4) a preliminary design, and 5) realistic cost and schedule estimates.[29] By 2009, FCS had spent 6 years and $18 billion achieving knowledge point 1 and a system level preliminary design review. Had it not been cancelled, that would have left around 4 years and $9 billion in development funding to complete knowledge point 2 and 3 criteria.[30]

Knowledge Point Two aligns with the Post-Critical Design Review and seeks to ensure the manufacturing technology and capacity exists to build the system. Critical information needed includes 1) release of at least 90 percent of design drawings, 2) operational testing of a system-level integrated prototype, 3) development of a reliability

growth curve, 4) accomplishment of a producibility assessment to identify manufacturing risks for key technologies, and 5) completion of a system failure modes and effects analysis. The object is to ensure readiness to build and conduct testing on production representative prototypes.[31]

Knowledge Point Three aligns with the decision to start production. Critical criteria include 1) the identification of key product characteristics and critical manufacturing processes, 2) demonstration that critical processes are in statistical control, 3) demonstration of the critical processes on a pilot production line, and 4) testing of production-representative prototypes.[32]

As part of the Defense Acquisition Board review and annotated in the acquisition decision memorandum the Army was directed to cancel the FCS acquisition program, terminate the manned ground vehicle development efforts, rapidly field ready-to-go capabilities and products to all combat brigades, and plan for an Army-wide modernization plan of integrated acquisition programs, including one to develop ground combat vehicles. [33]

Lesson Learned

Determined to learn from the past failures, Army Secretary John McHugh commissioned a review and analysis of Army acquisition. Published in January 2011, the Decker/Wagner Task Force report: “Army Strong: Equipped, Trained and Ready: The Final Report of the Army Acquisition Review” reiterated the Army’s record of too many schedule slippages, cost over-runs, performance shortfalls and failures to deliver required capabilities that “align with the Army operational tempo/cadence.”[34]

Fully committed to making changes the Army developed an implementation plan for 63 of the Task Force’s 76 recommendations.[35] Expected to be complete by the

summer of 2013,[36] many of the process lessons have already been executed. The use of tailored requirements management, affordability analysis, and knowledge based acquisition should reduce program risk and match resources to requirements. The Army's development of an overarching modernization strategy that combines an agile-lifecycle technology insertion process and capability set management will enable the Army to successfully field effective, affordable and timely land-power capabilities. The key to adherence rests in changing practitioner cultures through both incentives and enforcement.

The March 2012 General Accountability Office assessment for Congress of selected acquisition programs indicates that the Army is improving its use of knowledge-based acquisition tenets to meet evolving fiscal and strategic military environments. Fourteen Army programs are listed in the report. However five have either not passed the program inception decision point or are undergoing significant restructuring to improve the likelihood of a successful outcome.

As mandated in acquisition guidance since 2008, all nine programs that received acquisition executive approval and funding to proceed into the engineering and manufacturing demonstration phase completed a preliminary design review before approval. Completing the review has reduced the risk of cost and schedule over runs, but leadership is still allowing technology maturity to lag best practice recommendations. Eight of the nine programs demonstrated critical technology maturity in a relevant environment but only 44 percent demonstrated critical technologies in a realistic (operational) environment. One program did neither, declaring the hardware designs to be stable and went into production still working hardware heat and reliability

issues and software development.[37] Six of the nine programs have passed knowledge point two, completing the critical design review which included publication of a minimum 90 percent of the critical design drawings and successful system level prototype testing.

Four programs are in limited or full rate production and are testing production representative prototypes or production models in operational environments. Measuring manufacturing process maturity is the critical information needed at this point, but only three of the programs demonstrated a pilot production line and none of them demonstrated that the critical manufacturing processes were in statistical control.[38] While not perfect implementation this report shows improved implementation over the past practices used in the Future Combat System and documented in previous weapon system reviews. In addition, a few programs are applying technology maturity risk mitigation strategies such as requiring contractors to propose available solutions in lieu of the immature technology, conducting extensive modeling and simulation, and planning full-scale integration testing prior to production decisions to improve outcomes.[39]

The Army Equipment Modernization Plan

"There are a lot of naysayers out there about Army acquisitions … The myth is, Army acquisitions can't deliver," said Lt. Gen. Bill Phillips. "The truth is, we deliver for our soldiers. We've delivered yesterday, we deliver today and we'll deliver tomorrow."[40] Using the current mission in Afghanistan - proof of support rests in the successful fielding of the upgraded Mine Resistant Ambush Protected Vehicles (MRAP) and the all-terrain variants, the more than 60 upgrades to the M4 rifle, the M240L machine gun, Army drones and upgrades to all of the Army's major helicopter systems. Most dramatically is the success of the new Stryker 'double V' hull combat system - which

went from concept to fielding 300 of the total 760 planned vehicles in less than 24 months - and improving the odds of surviving an encounter with an improvised explosive device. With the exception of two out of 40 incidents, every soldier has walked away with just minor injuries.[41] Soldier survivability and effectiveness are always the right requirements, but given the reductions in the Budget Control Act of 2011 and the sequestration of another nine percent of the defense budget, Army leadership must decide if they were the optimal investments.

The Army equipment modernization plan has three foundational processes and a semi-annual integrated test and evaluation program that seeks to deliver affordable capabilities quickly. The first process is the Critical Portfolio Review (CPR) which balances requirements and resources. These reviews align stakeholders with a portfolio of systems, validated capability needs and a mandate to eliminate unnecessary redundancies and recommend modernization priorities. The second is a modernization process which focuses on closing the gaps using knowledge based acquisition practices, competitive prototyping, incremental technology insertion and where applicable the Army Agile Capabilities Life Cycle Process. The third process, Capability Set Management, is designed to pair an entire Brigade Combat Team with a total equipment package as the team moves through the Army Force Generation Model.

Requirements and Affordability

The CPR is an iterative and recurring senior leader mechanism that looks horizontally and vertically across all materiel requirements and solutions of a similar portfolio.[42] The representatives include the major stakeholders: the buyers from the Army equipping and requirements community, the vendors from industry and the accountants from the budget and cost estimation communities. The iterative nature

allows the process to keep pace with the changing strategic and operational environment and technology availability. Consensus among these key stakeholders then informs the decisions on how to balance the requirements with the available resources. [43]

CPR Results: 2013 Equipping Strategy

Effective prioritization and stakeholder alignment will enable the Army to champion its equipping and modernization strategy through the turbulence of resource reductions and economic uncertainty. As part of the 2013 budget and prioritization process the Army published its strategy focused on three program groupings: 1) Network the Force; 2) Replace, Improve, or Transform Combat Platforms; and 3) Empower, Protect and Unburden the Soldier.

Network the Force is the number one priority because this group of programs will provide a secure and common joint architecture that synchronizes with current real-time information, provide broadband capabilities to commanders' on-the-move and voice/data/imagery to company and platoon level. The key programs that meet this objective are Warfighter Information Network-Tactical (WIN-T), Joint Tactical Radio System (JTRS), Joint Battle Command-Platforms (JBC-P), Distributed Common Ground System-Army (DCGS-A), and Nett Warrior. These are technologies and capabilities that can be employed now and improved for implementation into future systems. Information distribution, dominance and decision support platforms are central to enabling a smaller but more capable force structure. [44]

The second group focuses on replacing, improving and/or transforming key ground combat, utility, and aviation platforms. Replace the Bradley Infantry Fighting Vehicle (IFV) with the Ground Combat Vehicle (GCV) a new program that will

accommodate an entire Infantry Squad, balance mobility with survivability and provide overmatch in lethality. Replace the aging M113 armored personal carrier family of vehicles with the Armored Multi-Purpose Vehicle (AMPV) providing improved protection and mobility. Improve the Abrams, non-IFV Bradleys, Paladin and Stryker Vehicles - with the lead budget priority in 2013 being Paladin Integrated Management (PIM) which will provide existing, low risk technology upgrades to the self-propelled Howitzer fleet. The Light Tactical Vehicle program modernizes the wheeled vehicle fleet with the first network-ready vehicle providing protection while allowing more maneuverability. The Army recognizes a continuing requirement for a light, armed helicopter for manned armed aerial reconnaissance, surveillance and light attack missions. This program will upgrade the high demand Kiowa Warrior (KW) with an improved sensor package.[45]

The third group focuses efforts to empower, protect and unburden the Soldier as a weapon platform by focusing efforts that enhance the lethality, protection, situational awareness and mobility of the individual Soldier. This focus group consists primarily of small arms and crew-served weapons, shoulder-fired and vehicle-mounted missiles, mortars, soldier sensors and lasers, night vision devices, body armor, soldier clothing, individual equipment, parachutes, unmanned ground vehicles and limited tactical communications equipment.[46]

Appetite Suppression

Layered below the Critical Portfolio Review is one of the most challenging aspects of effective acquisition management: requirements management. Instead of achieving “sufficient for the tasks at hand… or just barely good enough,”[47] functional capabilities managers in the Army’s Center’s of Excellence (COEs) continue to push the edge of physics and system performance. Each of the programs listed in the portfolios

above has a team of advocates led by the capability managers and sponsored by the senior leadership of each COE. These advocates validate capability gaps and develop a list of desired performance characteristics and key attributes such as top speed, carrying capacity, impact resistance, durability and fuel efficiency. These characteristics are then combined with scenarios of how or where the materiel solution will be used such as arctic, desert, mountain, jungle, urban and off-road or highway. The difference between the acceptable and best performance is usually measured in cost and schedule. These trades require active participation by all the stakeholders.

Often the capability manager's did not participate in affordability discussions, leaving many of the trade-off decisions to resource and acquisition program managers. While this technique preserves the functional capabilities managers' plausible deniability to their constituency it most often undermined program support across key stakeholders.[48] Additionally, some stakeholders equate "good enough" solutions with low quality ones. The reality is that the solutions are technically acceptable. This is not an excuse for acquiring less capable products, because capability is in the eye of the beholder, but the situation is about balancing the law of diminishing returns. Applying scarce resources to achieve more capability than necessary does not serve the needs of the total force.[49]

Using the Critical Portfolio Review process, senior Army leadership is forcing the Centers of Excellence to make informed trade-off decisions between requirements and cost. A dramatic example is found in the case of the Joint Light Tactical Vehicle (JLTV), where an analysis of the survivability and transportability requirements uncovered a potential cost savings trade-off that reduced the production unit cost from $500,000 to

$250,000.[50] The requirement to have the JLTV capable of being transported by a helicopter was inversely proportional to the need for added armor for soldier protection and system survivability. In this case the technology is too expensive to make it light and provide the needed protection for soldiers. There is still a need for a helicopter transportable vehicle, but that mission can continue to be filled by the current High Mobility Multipurpose Wheeled Vehicle.

Fast and Faster Lifecycle Models

The second foundational policy reinforces adherence to the use of modular designs, incremental modernization plans and encourages use of the Army's Agile Capabilities Life Cycle process where appropriate. The purpose is to gain the tactical advantage through smart sourcing techniques while hedging against the probability of changes in threat or technology. New and improved capabilities are delivered by selecting more mature commercial and military technologies and enforcing short two to three years development time lines in contracts through the appropriate use of incentives. Changing the culture from "all and now" to one that supports product improvements, capability growth potential, and smart production buying can balance production economics with utility obsolescence.[51] The Apache helicopter and the Joint Light Tactical Vehicle (JLTV) illustrate the principals of modularity and incremental modernization.

The AH64A Apache helicopter, first delivered in 1984, was designed to take incremental technology insertions and in doing so has maintained its dominance as a multi-mission combat helicopter. In 1994 the helicopter had fundamentally changed so much, it was renamed the AH-64D Apache Longbow based on the integration of the Longbow radar system which increased its survivability, lethality, and accuracy.[52] In

2006 the Apache Block III program entered system development to improve performance, situational awareness, lethality, survivability, and interoperability in order to prevent friendly fire incidents. Designated the AH64E, the block III program consists of one hardware and two software upgrades.[53] The AH64E is faster, can fly higher, and has modern color displays, improved radar interference protection, and the ability to control unmanned aerial vehicles. In August 2012, the Defense Acquisition Board approved full rate production of Block III. The Army plans to acquire 690 AH64Es through recapitalization of 640 older models and 50 new aircraft to replace battle damaged or destroyed helicopters.[54]

Similar to the initial Apache competition, the Joint Light Tactical Vehicle (JLTV) is employing a competitive approach to major system development. JLTV has just passed its milestone B entrance criteria and entered the Engineering and Manufacturing Demonstration (EMD) with three contractor teams competing for the production contract. Each contractor's JLTV is designed to be network ready off the production line and to easily accept upgrades to the network components, engine, armor, and armament.[55] As part of the 27 month, EMD contract, each team will deliver 22 vehicles by month 12 for network and mission command component integration and then participate in the operational test phase. With only 12 months before delivery there is little time for additional development work, driving the teams to employ tested, ready and commercially available components.[56] Following a robust operational testing phase, likely to occur in conjunction with a future Army's Network Integration Evaluation, the Army will select one manufacture to deliver 20,000 vehicles with potential options for a total of 55,000; low-rate-initial-production would begin delivery in 2015.[57]

The Apache and the JLTV both used the traditional Defense Acquisition Management framework (figure 3) to govern phases and decision points. While this framework is most appropriate for systems that have a 2-6 year development cycle, the Army's Agile Life Cycle Capability Process (figure 4) is more appropriate for development and acquisition cycles that are less than two years. The agile process evaluates procurements and development options, against prioritized requirements and fiscal realities. While seemingly focused on the urgent or emergent needs of combatant commanders, this construct has a greater capacity to adapt through more frequent purchases of smaller quantities as technology matures and the capabilities gaps are discovered. In addition this approach promotes increased independent research and innovation by industry to keep pace with technological advancement and react to innovative adversaries and threat changes. The additional private investment and emphasis on research and development may provide the next revolutionary advancement in military affairs.[58]

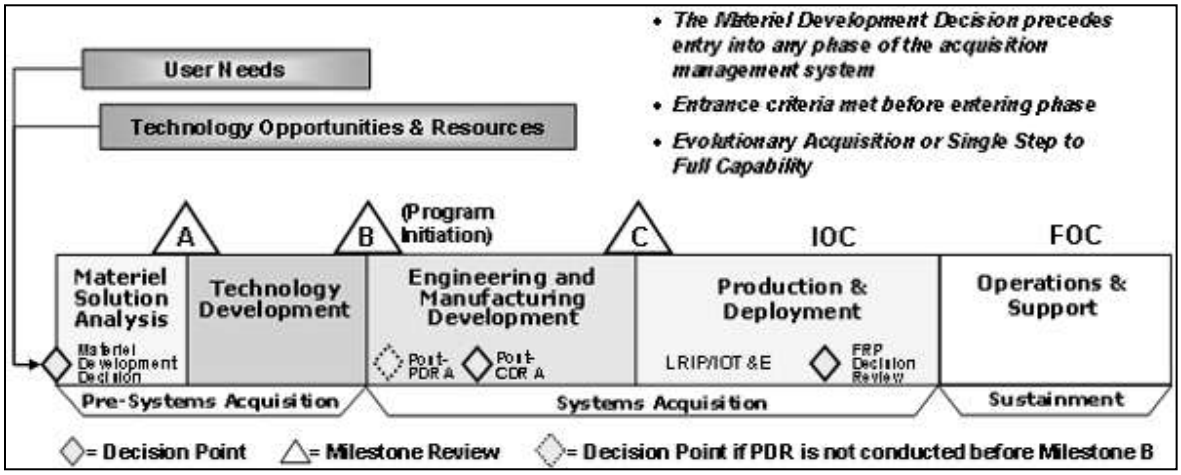

Figure 3. The Defense Acquisition Management System[59]

Given the rate of change in computing power, throughput, bandwidth, and the proliferation of applications, the Army can no longer keep up using the linear traditional acquisition process. The Army cannot afford years to test and validate a product whose life-cycle may only span months.[60] The seven-phase agile process is designed to encourage both large- and small-scale industry involvement and synchronize development and fielding efforts that could lead to increased competition and lower costs. [61]

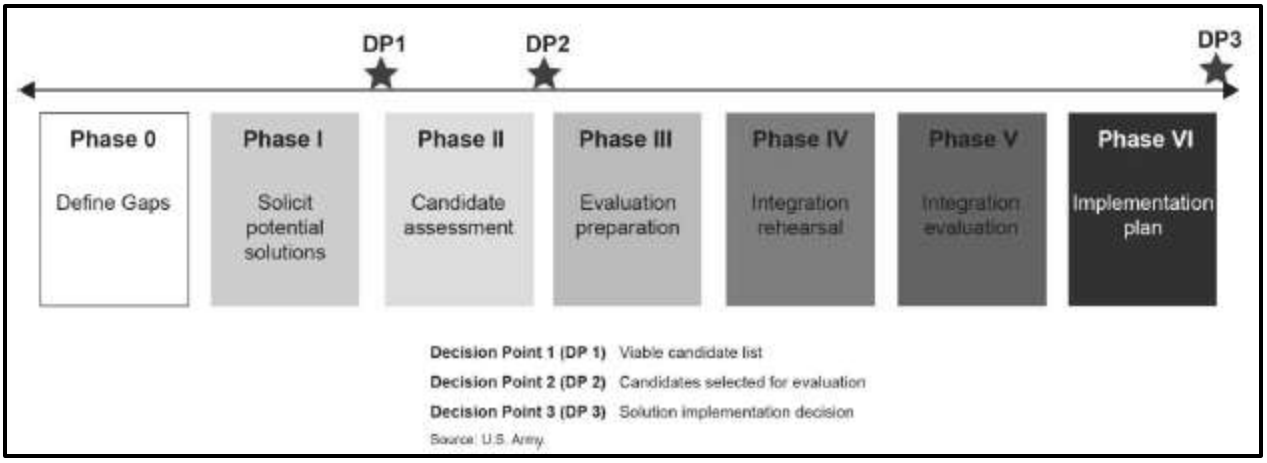

Figure 4. Army Agile Capabilities Lifecycle Process[62]

During Phase I, the Army requests white papers, proposals and candidate technology descriptions from industry to fill an identified capability gap such as a network router to connect a moving command and control platform to the Army Warfighter Network. The most promising proposals are selected to provide equipment or prototypes for integration validation at the network integration laboratory at Aberdeen Proving Grounds, MD. Once compatibility, interoperability and other technical standards are met, the Army contracts for the most technically acceptable solutions to participate in one of the semi-annual Network Integration Evaluations (NIE) at Fort Bliss,

TX. The Brigade Modernization Command leads phases III to V of the process and is responsible for integrating candidate systems with existing network capabilities of the 2nd Brigade, 1st Armored Division. The brigade is equipped with every vehicle platform currently in the Army inventory, and all its enabling support organizations. Each NIE lasts for approximately 6 weeks and upon conclusion (decision point three), the Army decides whether or not to buy and field the equipment. [63]

The restructure of Nett Warrior program demonstrates the utility of the Army's agile acquisition process to provide key decision support knowledge, improved capability, and significant fiscal savings. Nett Warrior, an Army program of record, used the traditional defense acquisition management system to provide friendly and enemy force locations and situational awareness down to the individual soldier. The original developmental products were provided to soldiers at the Network Integration Evaluation and tested in expected operational scenarios under battlefield environmental conditions. The observations of the test community and the soldiers' candid feedback uncovered significant utility challenges.[64]

Originally a 14 pound computer worn in a backpack with a heads-up display monocle worn over a soldier's eye; Nett Warrior was criticized severely for weight, size, energy consumption, usefulness, and in general a lack of mission value. In response, the Army announced to industry it needed the ability for individual soldiers to see where friendly troops and enemy fighters are located, and that it was willing to accept an 80 percent solution if a commercially available product could be integrated immediately and doing so made sense. The result was a cost savings estimated at $800 million and the

deployment of a force-tracking Android program that operates on a slightly modified commercially-available Smartphone.[65]

The first iterations of the NIE in 2011 were used to document the integrated network baseline and implement a common operating environment. Current iterations of NIE link the acquisition process to the third foundational process, Capability Set Management, which deploys a completely integrated network across brigade combat team platforms in two-year increments. Each fielded increment then becomes the new baseline for modernization and capability set management. [66]

Just-in-Time Fielding

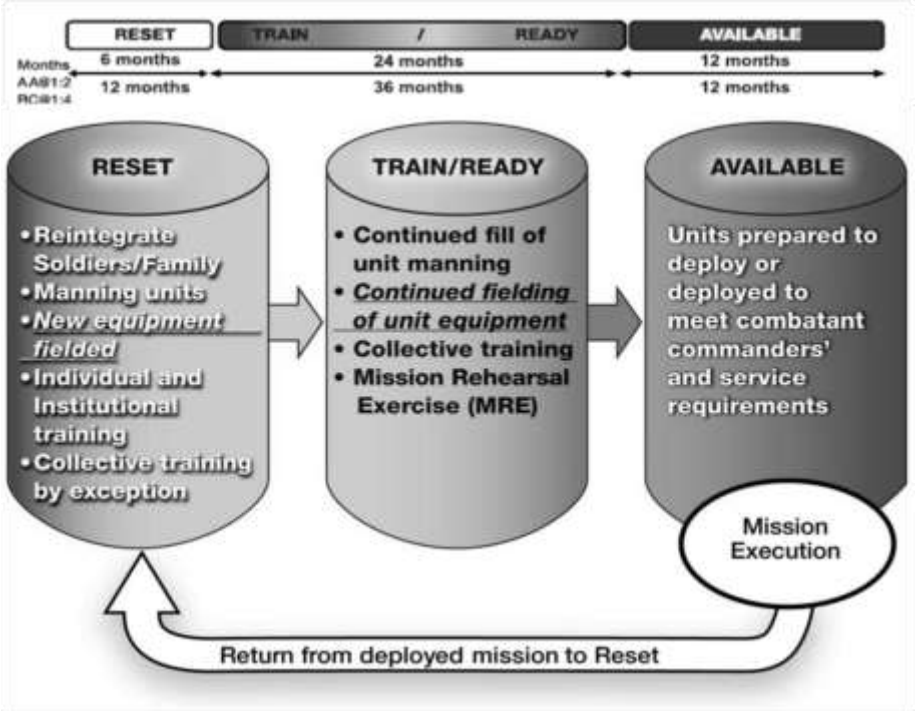

Figure 5: The ARFORGEN Model[67]

Capability Set Management synchronizes the production and distribution of equipment to units using the Army Force Generation (ARFORGEN) model in figure 5.

The ARFORGEN process cycles Army brigade combat teams through three force pools: RESET, Train/Ready, and Available in order to sustain current commitments and meet unexpected contingencies. This process provides increased readiness over time and delivers a steady and predictable supply of trained and ready modular forces. [68]

During the RESET phase, the Army acquisition process defines and delivers a capability set based on an evaluation the operational environment and an available suite of combat systems and enabling capabilities. During the Train and Ready phase those systems are integrated with the forces during realistic operational exercise to develop the techniques, tactics and procedures for employment of the capability set. Once in the available pool, the combatant commander definitively knows the land combat power available to deploy. [69]

Currently Capability Set 13 includes over 600 separate systems and vehicles and thousands of individual pieces of equipment. The centerpiece of the capability set is not the Mine Resistant Ambush Protected (MRAP) vehicles but the network and tactical communications. Two of the newest capability upgrades that have been in development are “mission command on the move” and increment two of the Warfighter Information Network-Tactical (WIN-T) Increment 2 program. “Commanders will now have a mobile command center with the same situational awareness and communications capabilities they'd have in a static command post.”[70]

The policy changes that facilitated development of innovative strategies such as Agile Capability Lifecycle Process, Network Integration Evaluation and Capability Set Management have achieved at least a tenfold return on investment. The execution costs of the first four NIEs through 13.1 will total somewhat less than $600 million over

two years, however program changes as a direct result of NIE testing have yielded approximately $6 billion in programmed cost savings.[71] Additionally, as the number of systems and platforms entering the NIE process continues to grow, the actual cost of holding each event continues to drop. Estimates suggest that by the time the Army executes NIE 13.2 and NIE 14.1 in 2013 the annual execution costs will be reduced by nearly $85 million or one-third from the FY 2011 total of $299 million. Projections for 2014 suggest that the combined costs of NIE 14.2 and NIE 15.1 may save an additional 25% due to efficiencies and process improvements.[72]

System of systems integration and portfolio management issues will require innovative oversight strategies. As noted in a recent General Accountability Office, the Army still needs to fully define performance metrics to gauge progress or make informed investment decisions and there is no consolidated reporting and budgeting framework for the network portfolio. Additional challenges include the inability of some current force vehicles to accommodate the power, heating and cooling needs of the new networking equipment, and finding incentives for encouraging both industry and existing programs to implement new computing technologies and from each successive capability set baseline. Finally initiatives to improve efficiency and effectiveness of the network are necessary to handle each new radio, mobile computing device, drone video feed, force tracking application, and data download from the brigade network storage application (cloud).[73] While fire-power, horse-power, and decision-power are priority capability objectives, the Army needs to apply its improved modernization and acquisition strategy to the power – or energy part of the equation.

Applying the Network Approach to Operational Energy

Operational Energy (OE) is the energy and associated systems, information and processes required to train, move and sustain forces and systems for military operations in the context of warfighter activities and mission priorities.[74] From both the tactical and strategic perspective OE should be approached not as a characteristic or performance parameter, but as a system of systems that produces effects on the operational environment, our land-power capabilities, and mission command. There are many similarities and parallels between Operational Energy and Network operation and the Army should adopt a programmatic approach similar to the Army's Network the Force modernization efforts to include programmatic and budget authority for integrating operational energy initiatives inside and across Army weapon system and operational basing programs.

The Network-Operational Energy Analogy

In as much as the mission of the Army LandWar Network is to bring information technology to the tactical edge and enable mission command that is able to see first and strike first, operational energy is about generating overall land-power performance capacity and execution potential. Operational energy is about smart energy not just less energy. Smart energy is using energy to our greatest advantage through energy-informed operations. Mission command that supports energy self-sufficiency has the power to reduce not only energy costs, but casualties and resources associated with distribution and convoy protection. Energy informed mission command can increase the number of warfighters and systems available for combat operations. [75]

The Energy System Architecture (figure 6) illustrates the hierarchical layers from available and potential sources to energy informed mission command with operational decisions, actions, and effects.

Figure 6: Energy Systems Architecture[76]

A holistic model for operational energy starts with the energy source and ends with the mission command of all the warfighter functions. As energy and information technologies evolve their interdependence will force a programmatic approach to address the paradigm of information technology requiring more power and power management requiring more sophisticated and faster computing capacity.[77] Similar to communications network taxonomy, the energy systems architecture enables visualization of the merger between information and the components of an energy system to include the connectivity between the nodes, modes, states and probable uses. This process is enabled by established and future protocols and international standards such as 110/220 hertz and 50/60 cycle electronics, fuel formulations, Lithium-

ion batteries in standard sizes, or multi-fuel capabilities. Adoption of an open energy system architectures that is modular, interoperable and scalable, can mitigate operational threats and take advantage of energy opportunities. While it may seem difficult to imagine standards relevant to diverse forms of energy, think of the proliferation of plug and play peripherals, applications and widgets that routinely work together through interface standards and protocols such as 801.11 series WiFi, the internet Domain Name System, and hypertext transfer protocol.[78]

Just as most network improvements fielded by the Army over the last decade were focused on supporting operations in Iraq and Afghanistan, the Army's development and fielding efforts for smart energy technologies were too. Synchronization of funding and timelines for acquisition of power generation capabilities and energy efficient consumption reduction technologies were piecemeal and integration was largely the responsibility of the user. Recent Operational Energy initiatives to reduce power demand and develop alternative sources have included the Office of the Secretary of Defense's (OSD) Joint Net Zero Plus (NZ+) Joint Combined Technology Demonstration (JCTD) at the National Training Center (NTC), Fort Irwin, California and the Marine Corps Ex FOB program at Marine Corps Air Ground Combat Center (MCAGCC) 29 Palms, California. While these efforts have produced a number of improvements, efforts appear independent and unsynchronized.

Army Operational Energy Capabilities Management

In May 2011, the Department of Defense released its "Energy for the Warfighter: Operational Energy Strategy" to provide an overarching approach to energy management and achieve "More Fight, Less Fuel."[79] The strategy focuses on seven target areas Measuring Operational Energy Consumption, Improving Energy

Performance and Efficiency in Operations and Training, Promoting Operational Energy Innovation, Promoting the Development of Alternative Fuels, Incorporating Energy Security Considerations into Requirements and Acquisition, and Adapting Policy, Doctrine, Education, and Combatant Command Activities to facilitate smart energy.[80]

The corresponding Army response was articulated under the heading of Operational Energy Synchronization Efforts in the June 2011 Army Campaign Plan,[81] and the creation of the Operational Energy - Contingency Basing Task Force, under the Assistant Secretary of the Army for Installations, Energy and the Environment. The Task Force Director is responsible for monitoring the development and execution of short and long-term energy solutions across the Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities domains of the force management model.[82] This organization will have to act as both the capabilities manager and the lead systems integrator with no actual budget control authority over those executing the individual programs, initiatives, and requirements across the Army. Influence will only result from Army strategic leadership championing of achievement of the energy goals as reported in the annual energy budget certification required by Congress.

Results of current Army operational energy forums have prioritized 10 smart power initiatives for operational energy. They include Soldier Worn Integrated Power Equipment System, the Advanced Medium Mobile Power Sources, Apache Aviation Simulator, Tactical Fuels Manager Defense, Electrical Microgrids, Energy Savings performance incentives for LOGCAP contractors, Development of Contingency Basing Standards, Test and Evaluation of potential products and solutions, Improved Turbine Engine Program for Helicopters, Vehicle Modernization Programs, and Future Platform

Performance requirements. [83] By modeling the Operational Energy task force on the Network Integration Evaluation team and providing funding control for the development and employment of energy components in each capability sets, the Army will see improved results faster. Adoption of the Network Integration Evaluation and agile process will enable our industry partners and government research facilities to combine efforts and focus on both deploying mature technologies, while developing the science and technology investment strategies that will build an informed and secure operational energy network.

Just as the Army is leveraging agile and knowledge based acquisition for the plethora of components that make up the network, so should the Director of the Operational Energy –Contingency Basing Task Force to the development of an operational energy network that integrates tomorrow's materiel, design, and other technology improvements to increase freedom of movement, agility, endurance, flexibility and sustainability into the current and future platforms to meet the demands of Energy-Informed Operations.

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